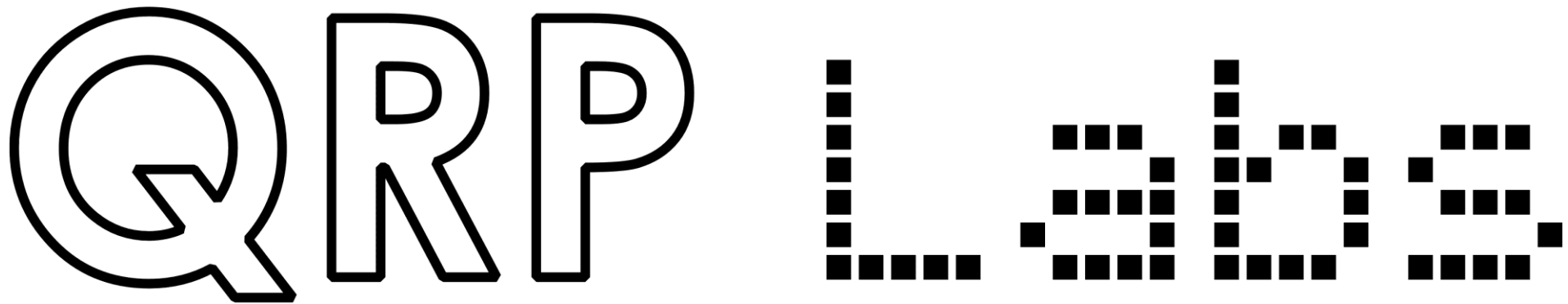


Development of the QSX transceiver kit

Portage County Amateur Radio Service

Monday 11-Feb-2019

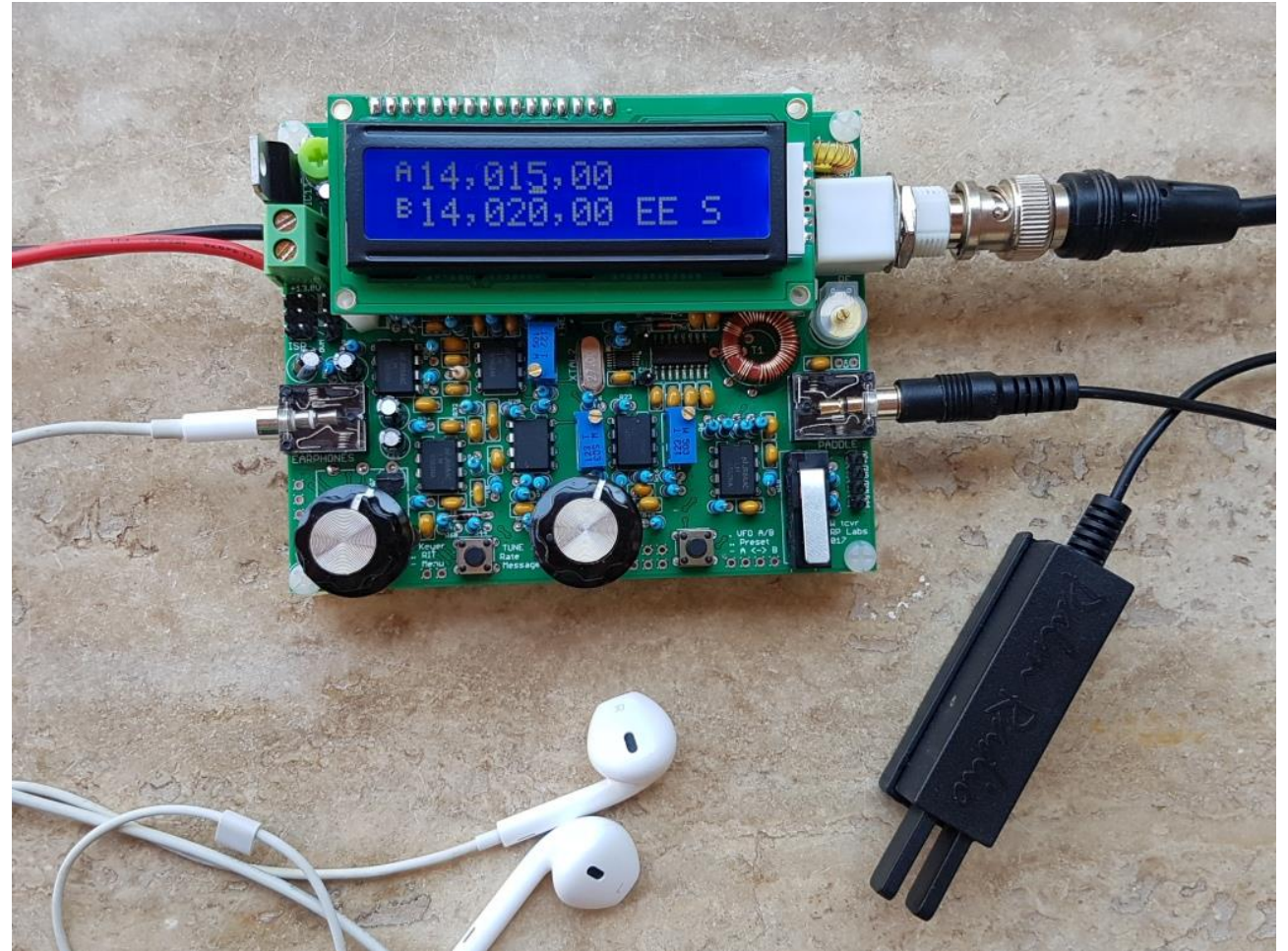
Hans Summers, G0UPL



<http://qrp-labs.com>

QCX 5W CW transceiver kit

- **Q**RP Labs **C**W **X**cvr
- Introduced at YOTA 2017 summercamp buildathon
- Since 21-Aug-2017, over 6,600 kits shipped
- Mono-band CW transceiver with high performance, built-in test equipment, and loads of features



QSX transceiver kit

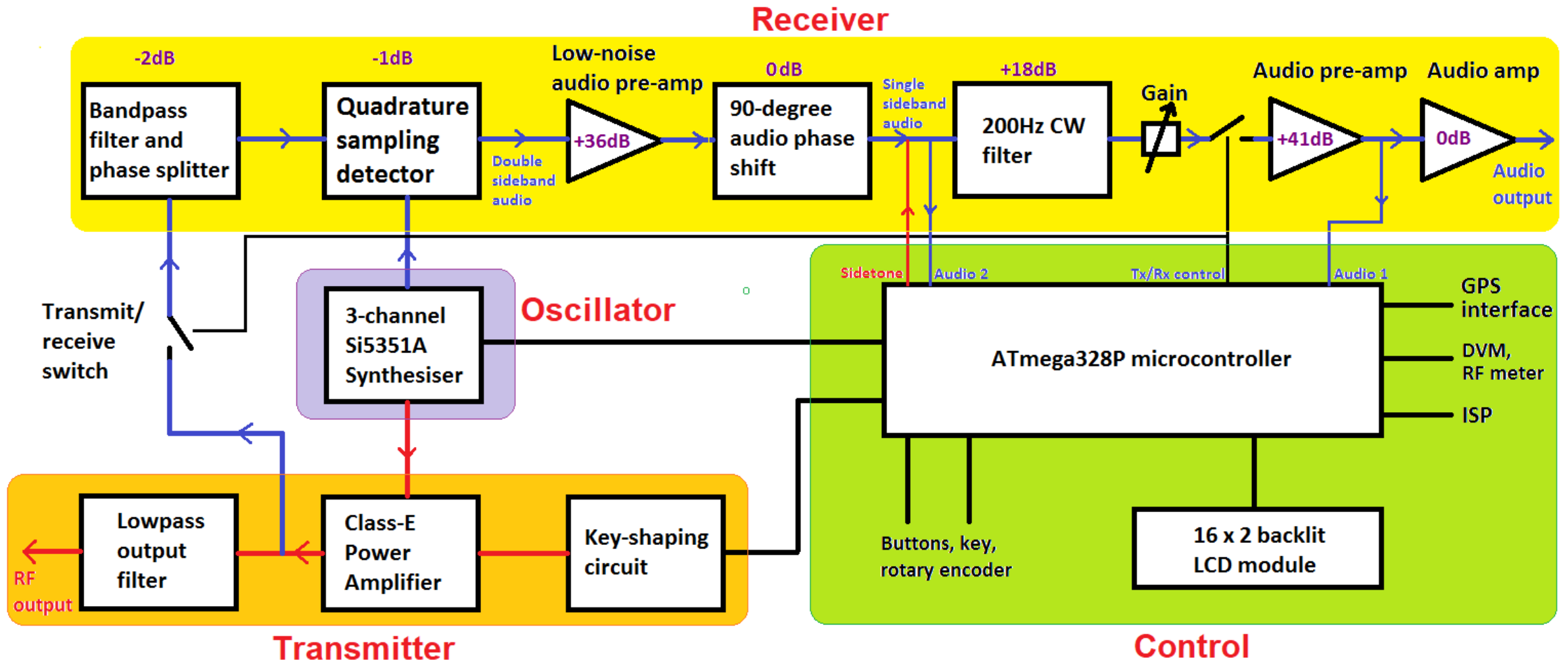
- **Q**RP Labs **S**SB/CW **X**cvr
- Introduced at YOTA 2018 summercamp buildathon in S.Africa
- Still under development
- AIM:
 - Very high performance HF transceiver
 - Very low cost
 - Tons of features
 - Easy, fun and education to build and use

COMING SOON



Transceiver architecture

- This is the old QCX 5W CW architecture... a good starting point for SSB?



Problems adapting that for SSB

Receiver:

- Audio phase shift must be wideband and accurate
- We're going to want AGC
- Multiple filters, for SSB and for CW and perhaps different filter widths
- More complex Band Pass Filter because we want it to be multi-band

Transmitter:

- For CW, the PA is easy (Class C, D, E are all Ok)... but for SSB we need a Linear – much more complex
- We need a proper SSB exciter, not just an oscillator feeding an amp
- We're going to want Speech processing
- Must handle CW key-shaping too

Software Defined Radio (SDR) to the rescue

SDR replaces some of the blocks of the radio transceiver with Digital Signal Processing by a computer

- Advantages:
 - Lots of flexibility to implement features
 - Software can be updated to easily add new features
 - Cost savings
- Disadvantages:
 - Requires a computer!
 - Requires high performance conversion between digital and analog
 - Digital Signal Processing sounds scary



SDR: solving the disadvantages

1. Requires a computer

- Use an embedded 32-bit ARM processor!
- STM32 series are popular, easy and low cost
- Plenty of processing power, at 168MHz



2. Requires high performance conversion between digital and analog

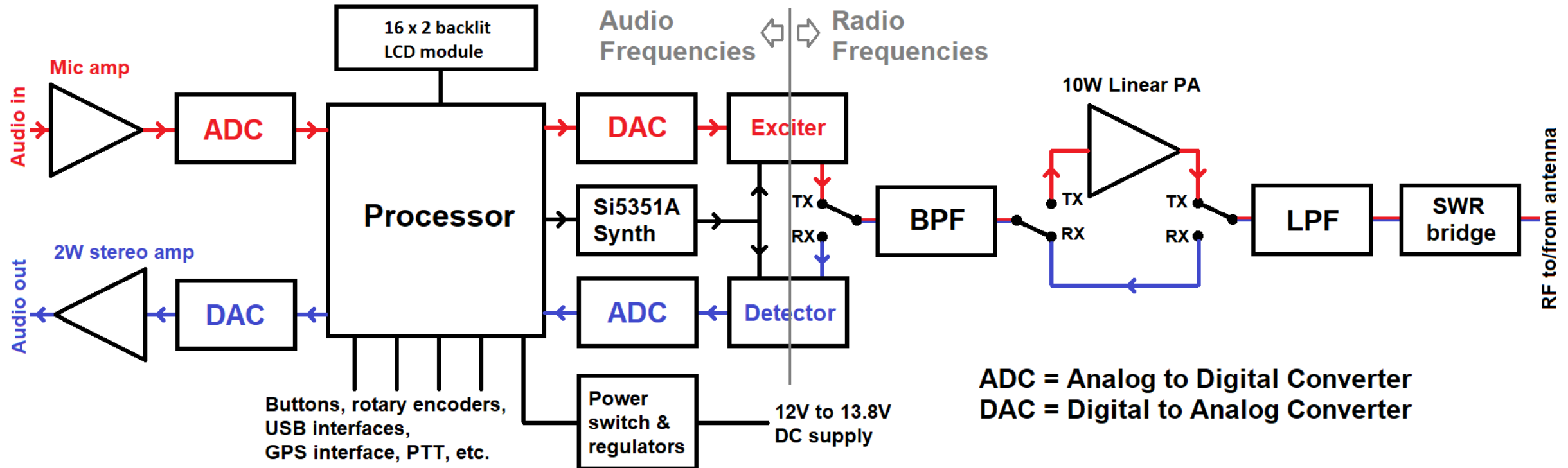
- 24-bit ADC and DAC chips are available
- Cost of Processor an ADC and DAC chip is LESS than the analog circuits they replace
- Some of the conversions can use the built-in 12-bit ADC and DAC in the processor

3. Digital Signal Processing sounds scary

- Lots of examples around the internet!

QSX Block diagram

- Key point: the cost of ADC + DAC + Processor is LESS than the analog circuit blocks they replace!



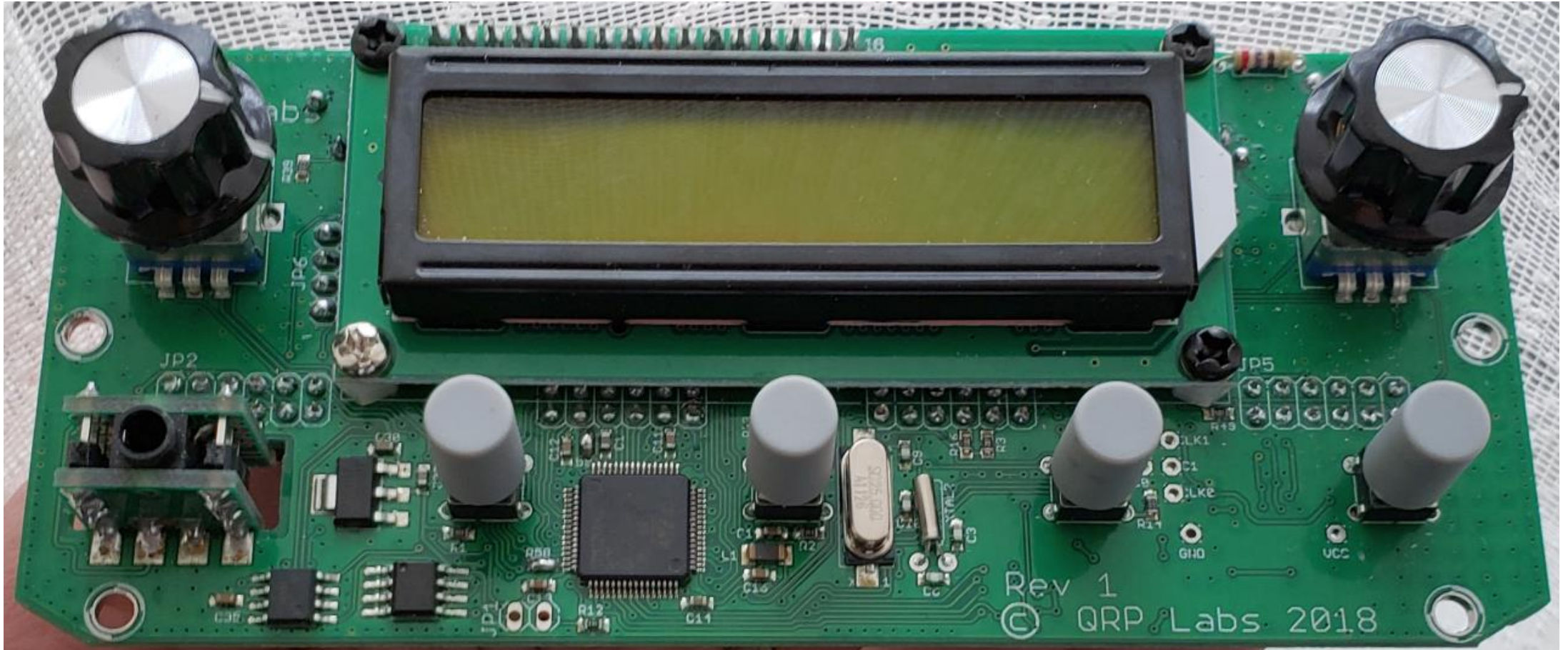
QSX features

- DSP (filters, AGC, Speech compression, noise reduction)
- Built-in test and alignment equipment
- SWR Bridge
- USB A and USB B connectors
- Paddle input for CW (built-in IAMBIC keyer)
- WSPR and QRSS modes beacon mode included
- GPS interface for frequency and time discipline, and beacon modes
- RJ45 connector for Kenwood/Yaesu style microphones
- Realtime clock (CR2032 battery holder)
- 10W power output CW, Digital or SSB

Performance

- Around 100dB dynamic range expected
- 24-bit Receiver ADC has 107dB dynamic range
- High IP3 front end mixer (Quadrature Sampling Detector)
- 12kHz IF mode (away from mains hum)
- Narrow Band Pass Filter per band, attenuates out-of-band signals
- Compliant with all regulations on harmonic and spurious output
- Good IMD transmit performance
- Variable transmitter power output 1 to 10W
- DSP features: sharp features, noise reduction, notch filter etc.

3 boards: Front panel, rear board, and PA board



Rear board and PA board



Enclosure



QSX mono-band or all-band option

- Initially a single mono-band version, for 40m by default
- Optional black anodized cut, drilled and silk-screen printed aluminium enclosure
- Optional 10-band all-HF filter board can be added later
 - 160m to 10m coverage
 - Individual band-pass receive filtering for each band

CW and SSB features

CW features

- Full or Semi-breakin (QSK)
- Laminar keyer
- On-screen CW decoder
- Message and frequency memories
- Full 10W Power output
- Raised-cosine envelope shaping
- Variable filter centre frequency and bandwidth

SSB Features

- Automatic Gain Control (AGC)
- Speech processing/compression
- Variable bandwidth filters
- 10W PEP power output
- Dual mic

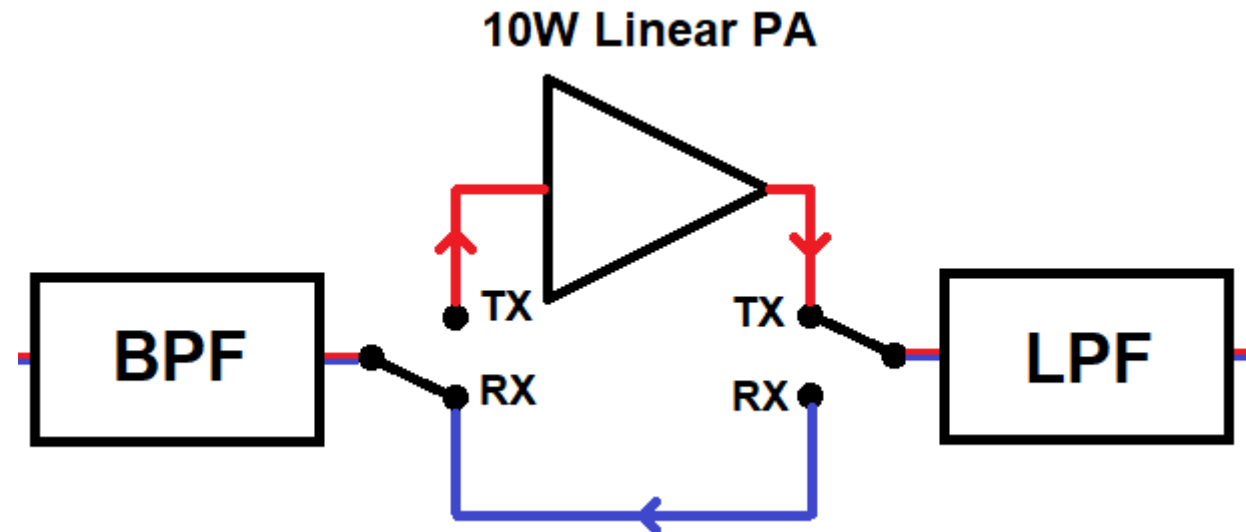
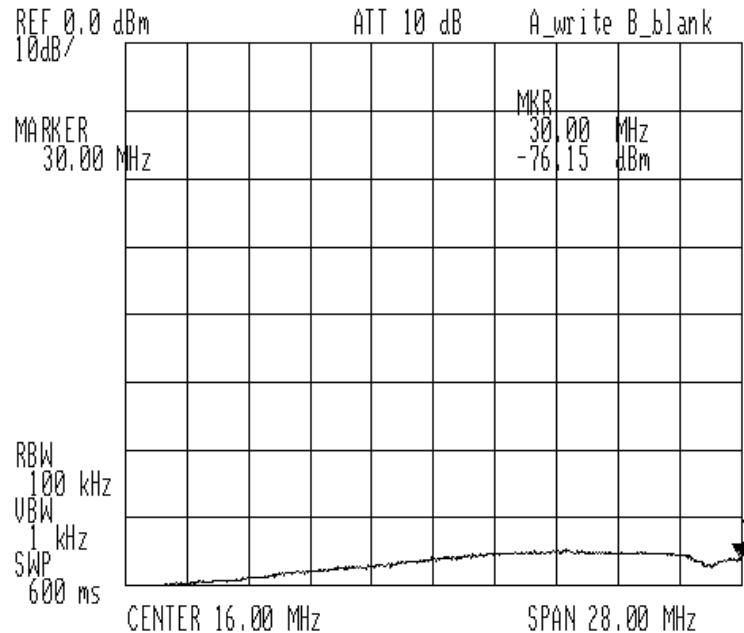


Digital and other modes support

- RTTY and PSK31 supported natively (no PC required)
 - USB keyboard text entry
 - CW to RTTY/PSK31 translator
 - RTTY and PSK31 decoding on-screen
- Connect to a PC with a common USB cable, for:
 - Digital modes: USB soundcard emulation: plug the radio into a PC and it will behave as a high performance 24-bit soundcard with a radio transceiver attached for it, perfect for digital modes
 - Virtual Serial COM port, for CAT rig control over the **same** USB cable
- Full 10W Power output continuous key-down (100% duty cycle)
- Also AM, FM modes

Transmit/Receive switch

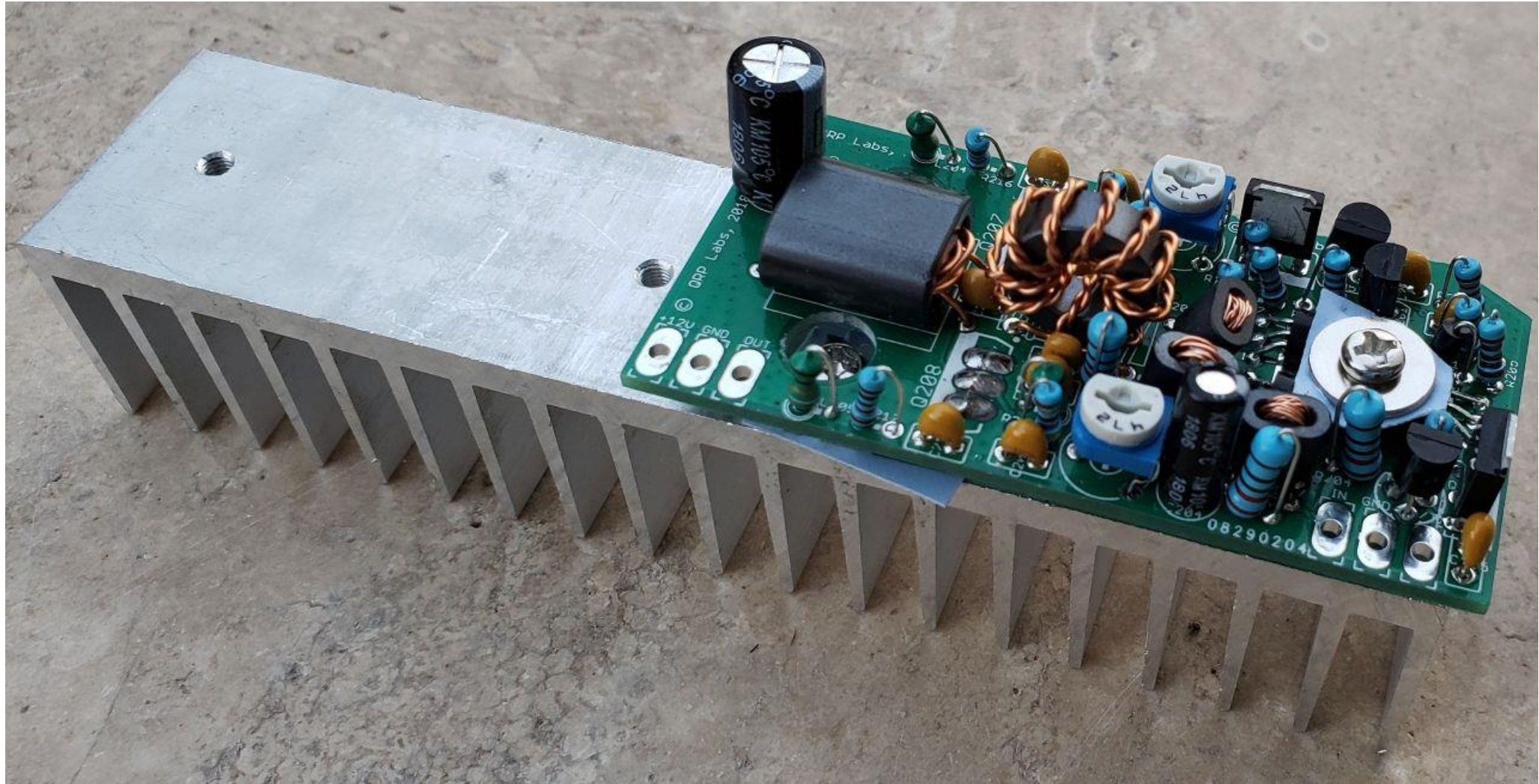
- All solid state, no relays: Fast and high performance (CW QSK)
- Low cost, high performance 1N4007 “PIN diode” switch
- RX bypass in “TX” mode has 70+ dB attenuation
- PA output to LPF only 0.1dB insertion loss in TX



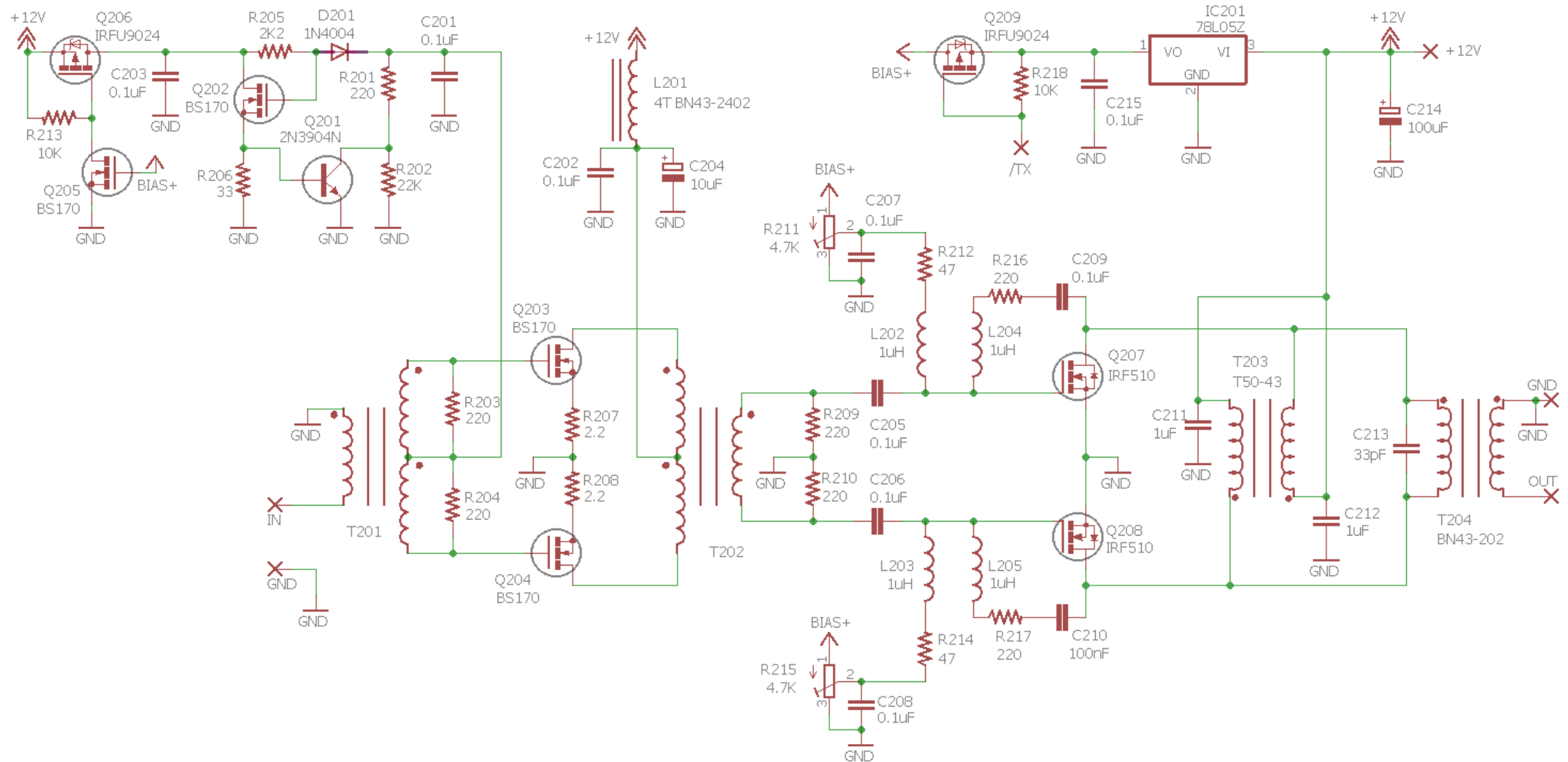
Qsx 10W Linear PA module

- Relatively massive heatsink allows 100% duty cycle operation at 10W
- Low cost (inexpensive IRF510 MOSFETs)
- 26dB of gain, flat to +/- 1dB across 160m to 10m
 - The Qsx SDR provides power output equalization, 10W on every band
- Push-pull BS170 driver, and push-pull IRF510 final, for excellent linearity
 - 80m test at 10W: 2nd harmonic -38dBc, 3rd harmonic -31dBc (before Low Pass Filtering)
- Through-hole plated PCB, all through-hole components (no Surface Mount Devices)
- PCB size 69.69mm x 33.97mm (2.744 x 1.338 inches)
- Standard inexpensive components throughout
- ROBUST:
 - Tested for 1 hour at full-power 10W, 100% continuous duty-cycle with no forced air cooling
 - Tested for 15 minutes at 20W, 100% continuous duty-cycle with no forced air cooling
 - Tested at 20V supply
 - Tested into open load, shorted load and various mismatches without instability (oscillation)

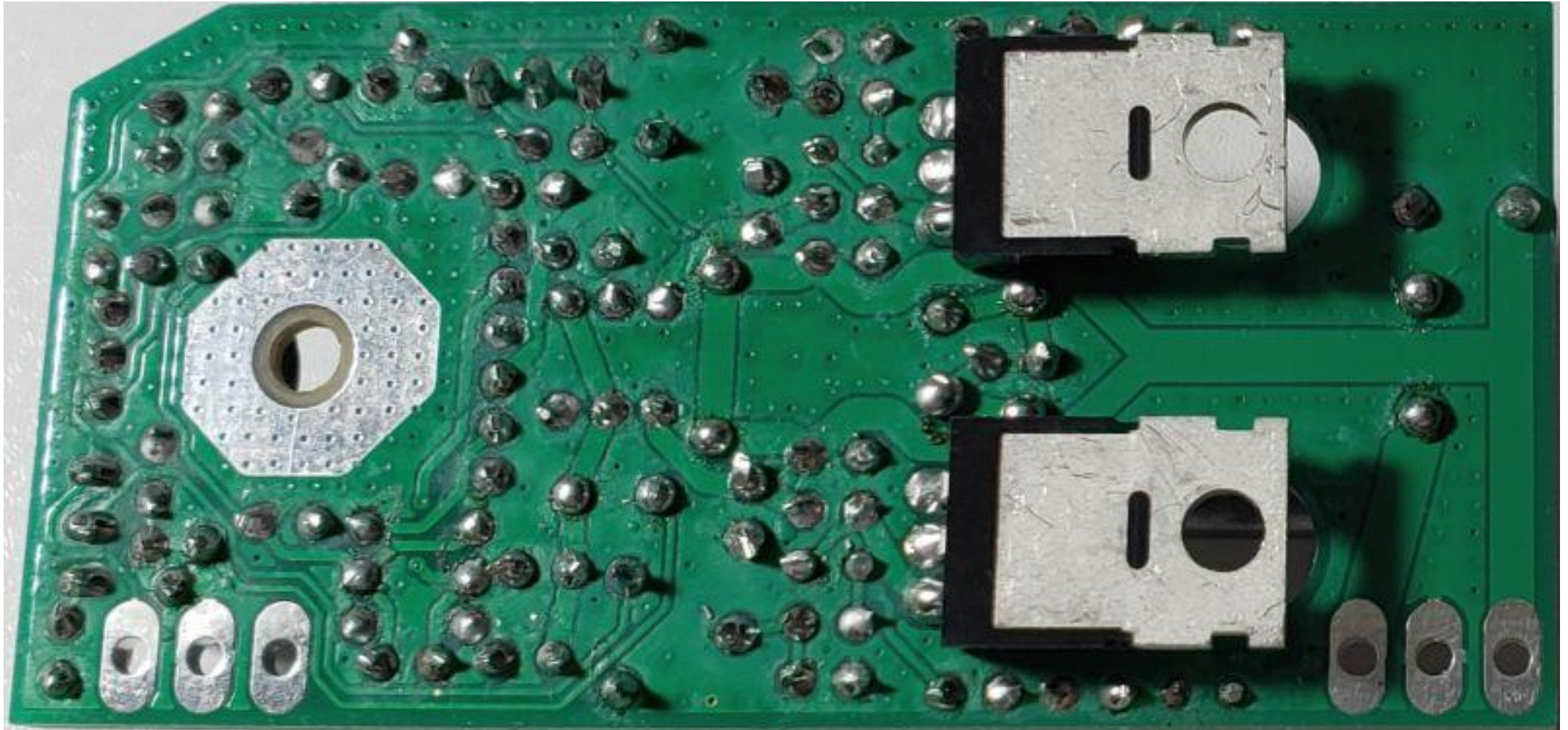
QSX Linear: heatsink 130 x 30mm, 25mm fins



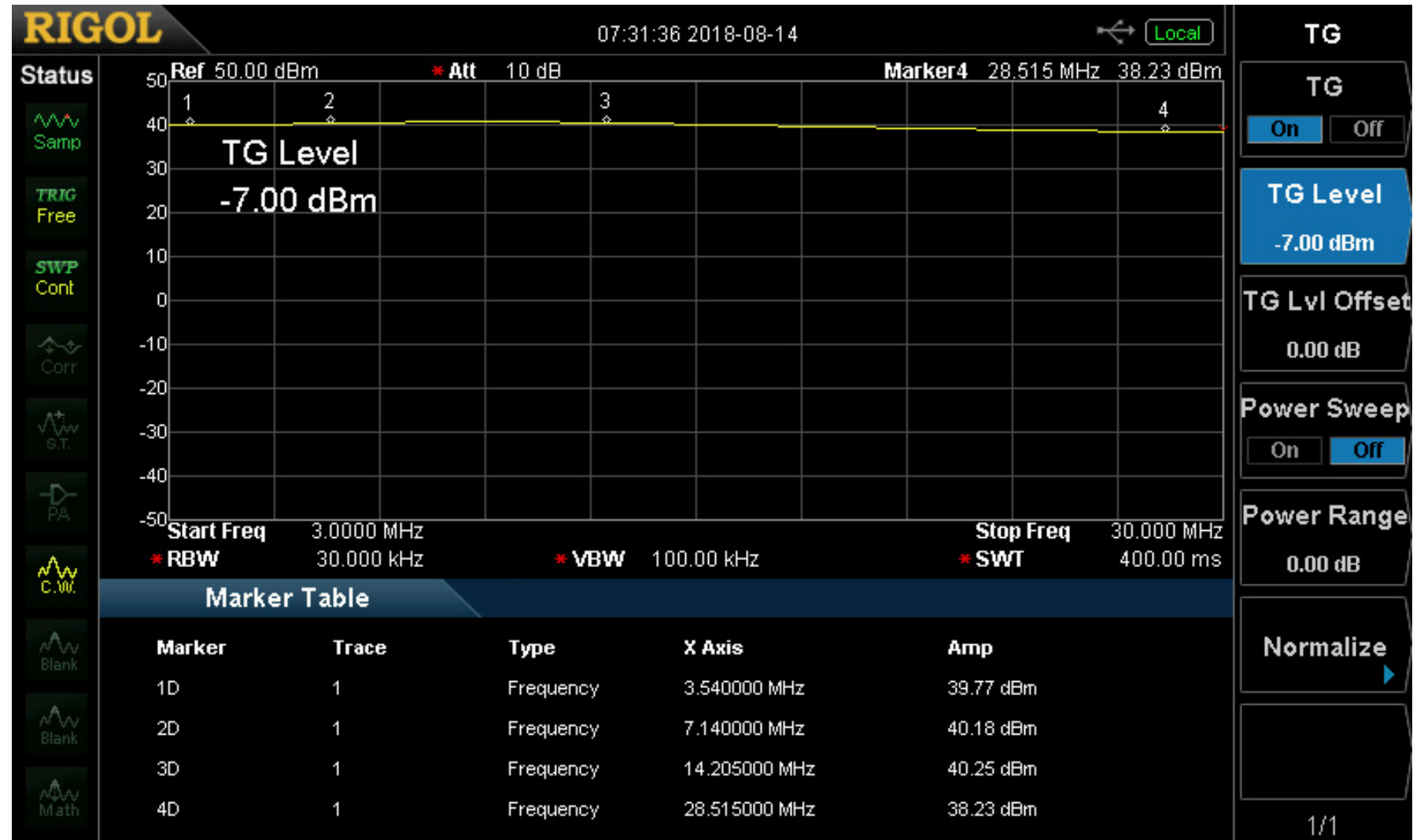
QSX Linear: circuit diagram



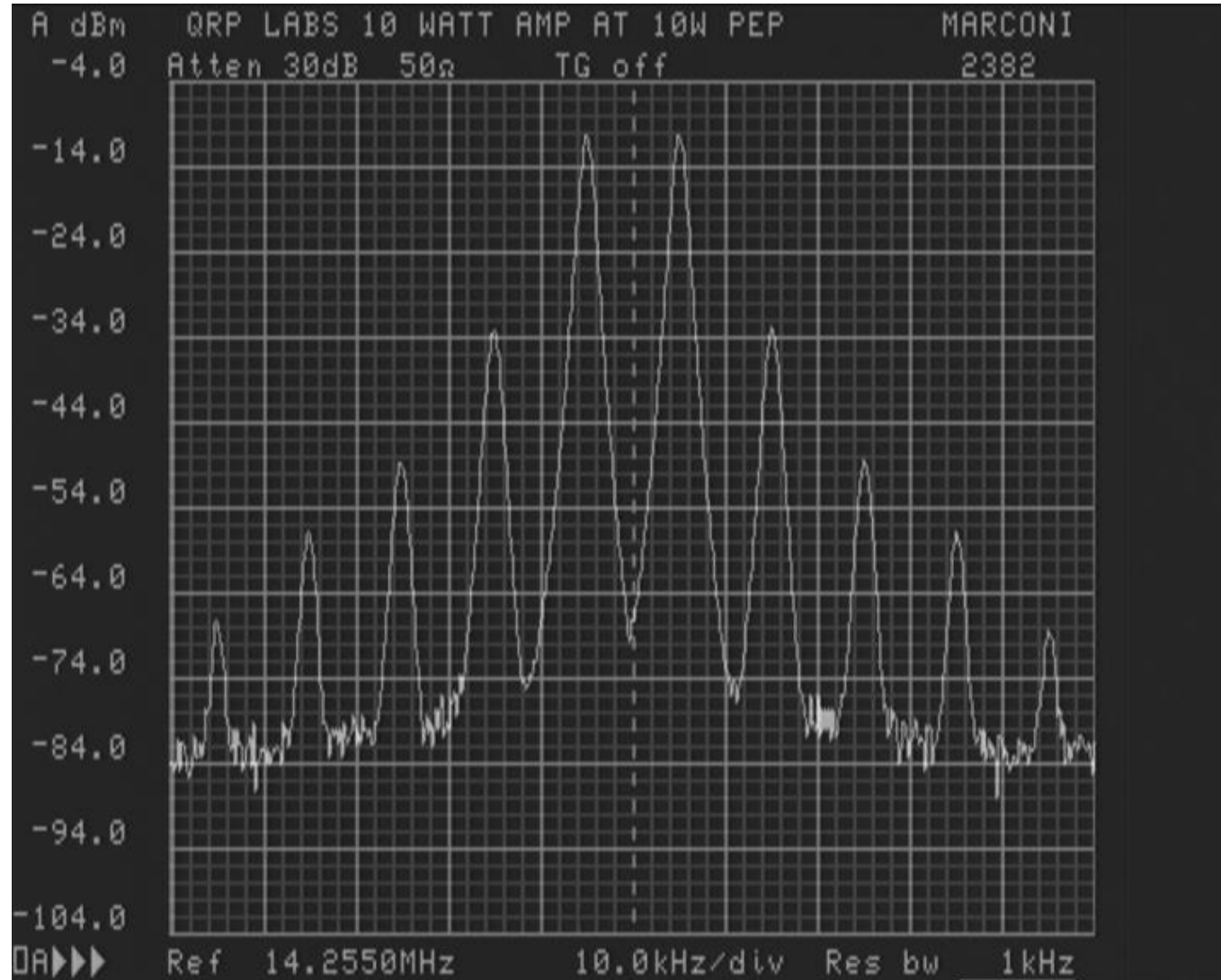
QSX Linear: symmetric layout



QSX 10W Linear PA module: gain



QSX Linear IMD3 -30dB, IMD5 -45dB (20m test)



- Two-tone test with 10kHz separation, at 10W PEP output with 12V supply
- Test of 10W Linear PA module only – full QSX transceiver IMD test will be run during final testing

Built-in test equipment

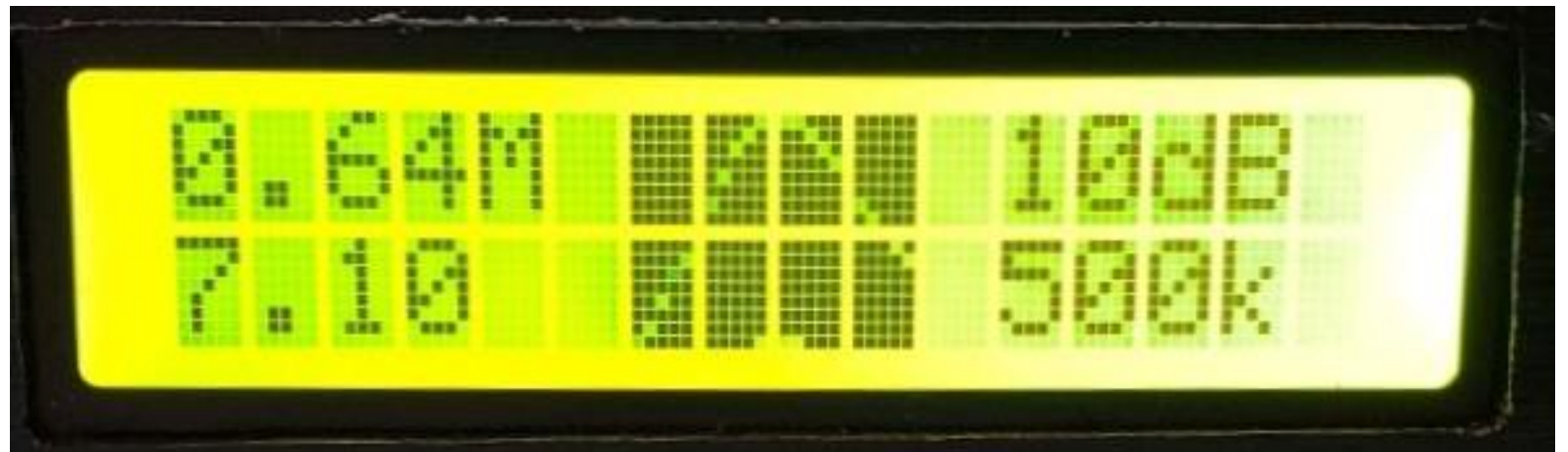
- Signal generator
- frequency counter
- DVM
- Inductance meter
- RF power meter
- SWR
- Spectrum analyzer



Spectrum analyser function for BPF alignment

Display shows:

- Filter bandwidth
- Center frequency
- Vertical scale
(dB/division)
- Horizontal scale
(Frequency/division)

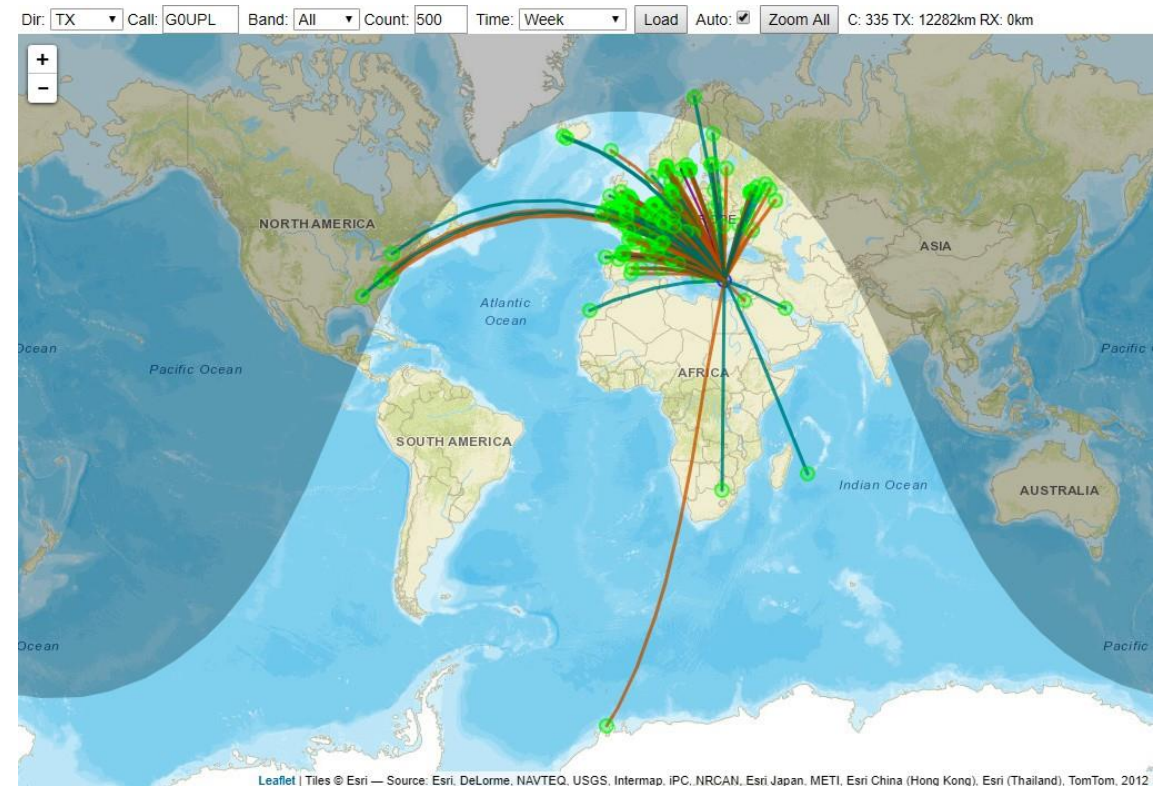


Rotary encoder knobs let you adjust center frequency and bandwidth

See YouTube video: <https://www.youtube.com/watch?v=bMoR3Q6gzM>

Weak-signal mode support (standalone, no PC)

- WSPR (Weak Signal Propagation Reporter)
- CW beacon, RTTY, PSK31
- FT8 beacon
- QRSS modes (QRSS, FSKCW, DFCW, Slow-Hell)
- Opera
- Pi4
- JT4, JT9, JT65 beacon
- ISCAT (A/B)
- See also Ultimate3S kit
<http://qrp-labs.com/ultimate3/u3s>

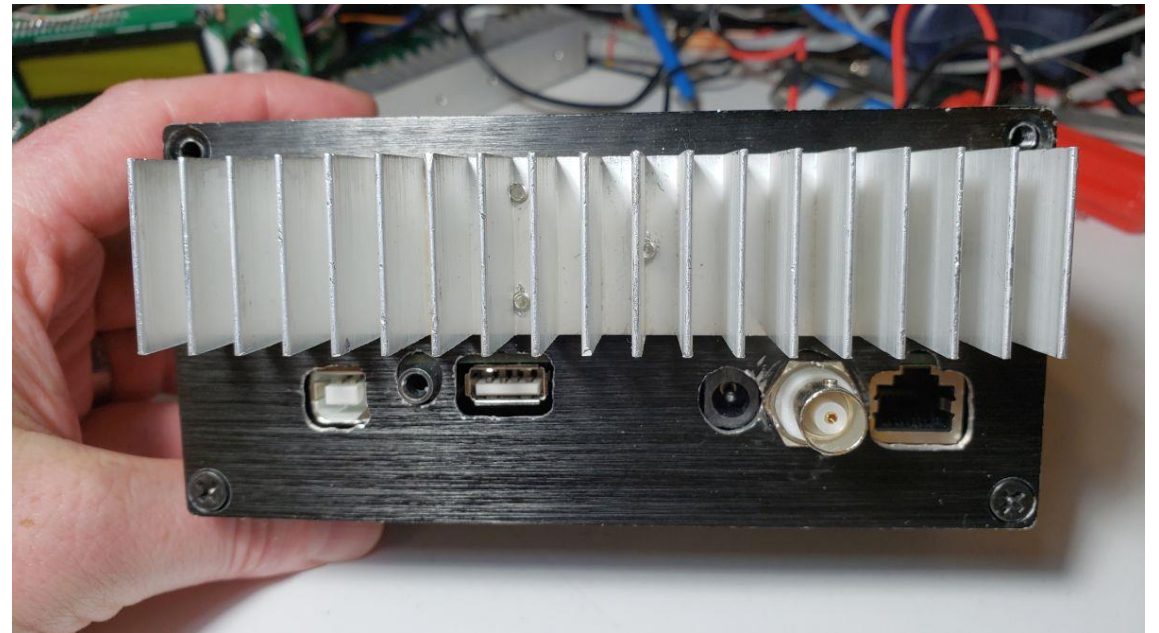


QSX scripting

- QSX is not Open Source!
- QSX emulates popular Kenwood TS-480 CAT control standard
- Very flexible scripting language, programs stored in EEPROM
- All QSX functionality can be scripted, in scripts entered over a serial terminal (or via USB keyboard, or via CW entry)
- All buttons and rotary encoders can be re-defined to your custom requirements and preferences

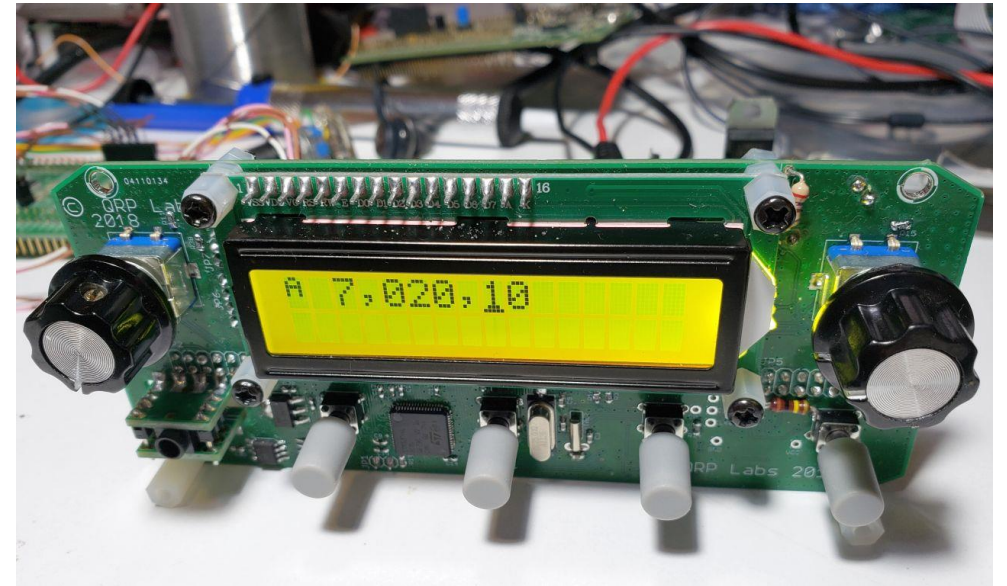
QSX firmware updates are easy!

- No specialized hardware or software required for programming
- Copy the firmware file onto a USB memory stick
- Plug USB memory stick into the back of the QSX
- Go to the setup menu and choose to upgrade firmware
- Takes a few seconds to reprogram itself
- See YouTube video: <https://www.youtube.com/watch?v=xzOv9szPnhI>



SUMMARY – see <http://qrp-labs.com/qsx>

- High performance all-band, all-mode 10W HF transceiver
- Fun, flexible educational, customisable
- Performance of a top-range radio at 1/10th the price
- Availability: 2-3 months (hopefully)
- Price target:
 - **\$75** basic 1-band QSX-40
(can also be built for any other single band)
 - **\$150** with all options:
10-band module and aluminium enclosure



QRP Labs

<http://qrp-labs.com>